CLAIMS

[1] A coding equipment which generates a coded signal that includes information for generating a signal at a high-frequency range by replicating a signal at a low-frequency range, the ranges being segments in a time direction and in a frequency direction, said coding equipment comprising:

a tone-to-noise ratio calculation unit operable to calculate, using linear prediction processing, a tone-to-noise ratio of the signal at the segmented high-frequency range and a tone-to-noise ratio of the signal at the low-frequency range to be replicated at the high-frequency range, the tone having signal components that exist intensely at a specific frequency range and the noise having signal components that exist regardless of frequency range;

an adjustment coefficient calculation unit operable to calculate an adjustment coefficient which is used to adjust tonal characteristics of the signal at the low-frequency range to be replicated at the high-frequency range, based on the tone-to-noise ratios calculated regarding the signals at the low frequency range and the high frequency range; and

an encoding unit operable to generate the coded signal that includes the calculated adjustment coefficient.

[2] The coding equipment according to Claim 1,

wherein said tone-to-noise ratio calculation unit further includes:

a high-frequency signal component calculation unit operable to calculate, using linear prediction processing, the tone components and the noise components which are included in the signal at the segmented high-frequency range;

a high-frequency tone-to-noise ratio calculation unit operable to calculate, using the calculated tone components and the noise

components, a high-frequency tone-to-noise ratio that is a ratio of an energy sum of the tone components to an energy sum of the noise components at the high-frequency range;

a low-frequency signal component calculation unit operable to calculate, using linear prediction processing, the tone components and the noise components which are included in the signal at the low-frequency range corresponding to the high-frequency range, the low-frequency range being to be replicated at the high-frequency; and

a low-frequency tone-to-noise ratio calculation unit operable to calculate, using the calculated tone components and the noise components, a low-frequency tone-to-noise ratio that is a ratio of an energy sum of the tone components to an energy sum of the noise components in the signal at the low-frequency range corresponding to the high-frequency range,

wherein the adjustment coefficient calculation unit is operable to calculate the adjustment coefficient based on the calculated high-frequency tone-to-noise ratio and the low-frequency tone-to-noise ratio.

[3] The coding equipment according to Claim 2,

wherein said adjustment coefficient calculation unit includes

a tonal restraint determination unit operable to determine that restraint on the tonal characteristics of the signal at the low-frequency range is necessary, when the high-frequency tone-to-noise ratio q_ hi(i) is smaller than a first threshold value Tr1 and the low-frequency tone-to-noise ratio q_ lo(i) regarding the low-frequency corresponding to the high-frequency range is greater than a second threshold value Tr2, and

said adjustment coefficient calculation unit is operable to calculate the adjustment coefficient according to equation 7, when as a result of the determination the restraint on the tonal

characteristics is necessary,

[Equation 7]

$$B_i = \begin{cases} 0, \text{ if } q\_lo(i) < Tr2 \text{ OR } q\_hi(i) > Tr1 \\ \left(\frac{q\_lo(i) - Tr2}{Tr3 - Tr2}\right)\left(1 - \frac{q\_hi(i)}{Tr1}\right) \quad \text{otherwise} \end{cases}$$

$$B_i = \min(B_i, 1)$$

[4] The coding equipment according to Claim 1 further comprising

a tone signal addition determination unit operable to determine whether or not a predetermined signal having the tonal characteristics is to be added to the signal at the low-frequency range to be replicated at the high-frequency range, based on the tone-to-noise ratios calculated regarding the signals at the low-frequency range and the high-frequency range,

wherein said encoding unit is operable to generate the coded signal which includes a determination result of said tone signal addition determination unit.

[5] The coding equipment according to Claim 4,

wherein said adjustment coefficient calculation unit is operable to calculate an adjustment coefficient which indicates a degree of the restraint on the tonal characteristics of the signal at the low-frequency range to be replicated, and

said tone signal addition determination unit is operable to determine whether or not the signal having the tonal characteristics is to be added after amending the tone-to-noise ratio of the signal at the low-frequency range according to reduction in energy of the signal components at the low-frequency range due to the constraints on the tonal characteristics of the signal at the

low-frequency range using the calculated adjustment coefficient.

[6] The coding equipment according to Claim 5,

wherein said tone signal addition determination unit is operable to amend the tone-to-noise ratio q_lo(i) of the signal at the low-frequency range according to the reduction in the energy of the signal components at the low-frequency range due to the restraint on the tonal characteristics of the signal at the low-frequency range using the calculated adjustment coefficient Bi, the correction being performed according to equation 9 when the determination is made as to whether or not the signal having the tonal characteristics is to be added,

[Equation 9]

$$q\_lo(i) = \frac{\sum_{t \subset T(i)} \sum_{k \subset hi} St^2(t,p(k))(1 - B(t,k))}{\sum_{t \subset T(i)} \sum_{k \subset hi} Sn^2(t,p(k))}$$

where t represents the number of samples from t=0 to t=T(i) in the time direction, and k represents k subbands included in a tone band hi segmented in the frequency direction.

[7] The coding equipment according to Claim 6,

wherein said tone signal addition determination unit is operable to determine that the signal having the tonal characteristics is to be added to the high-frequency range, when the high-frequency tone-to-noise ratio q_hi (i) and the low-frequecny tone-to-noise ratio q_lo (i) that is corrected in order to compensate the restraint on the tonal characteristics of the signal at the low-frequency range using the calculated adjustment coefficient Bi satisfy conditions indicated by equation 10,

[Equation 10]

$$q\_hi(i) > q\_lo(i) * Tr4$$

$$\text{and, } q\_hi(i) > Tr5, \text{ and, } q\_lo(i) < Tr6 \quad ,$$

where Tr4, Tr5, and Tr6 are predetermined threshold values.

[8] The coding equipment according to Claim 4,

wherein said tone signal addition determination unit is operable to determine whether or not the signal having the tonal characteristics is to be added to the high-frequency range, based on an energy distribution of the signal at the segmented high-frequency range and the tone-to-noise ratio of the signal at the high-frequency range.

[9] The coding equipment according to Claim 8,

wherein said tone signal addition determination unit is operable to determine that the signal having the tonal characteristics is to be added, when a signal having extremely high energy is found among a plurality of signals having relatively low energy at the segmented high-frequency range.

[10] The coding equipment according to Claim 1 further comprising:

a signal component calculation unit operable to calculate, using linear prediction processing, the tone components and the noise components which are included in the signal at the segmented high-frequency range: and

a component energy calculation unit operable to calculate energy of the signal at the high-frequency range and energy of the noise components included in the energy of the signal at the high-frequency range, based on respective energy of the calculated tone components and noise components,

wherein said encoding unit is operable to generate a coded

signal which includes information indicating the energy of the signal at the high-frequency range and information indicating the energy of the noise components included in the energy.

[11] The coding equipment according to Claim 10,

wherein said adjustment coefficient calculation unit is operable to calculate an adjustment coefficient which indicates a degree of the restraint on the tonal characteristics of the signal at the low-frequency range to be replicated, and

said component energy calculation unit is further operable to calculate the energy of the noise components included in the energy of the signal at the high-frequency range, after amending the energy of the tone components at the low-frequency range according to the restraint on the tonal characteristics of the signal at the low-frequency range using the calculated adjustment coefficient.

[12] The coding equipment according to Claim 11,

wherein said component energy calculation unit is operable to calculate the noise components of the energy at the high-frequency range by calculating a sum of noise components resulted from the signal at a subband added with the signal having the tonal characteristics and noise components resulted from the signal at a subband without being added with the signal having the tonal characteristics, regarding all subbands corresponding to the high-frequency range.

[13] The coding equipment according to Claim 11,

wherein said component energy calculation unit is further operable to calculate the energy of the noise components at the high-frequency range, depending on whether or not the signal having the tonal characteristics is to be added to the signal at the

low-frequency range to be replicated at the high-frequency range.

[14] A coding method of generating a coded signal that includes information for generating a signal at a high-frequency range by replicating a signal at a low-frequency range, the ranges being segments in a time direction and in a frequency direction, said coding method comprising:

calculating, using linear prediction processing, a tone-to-noise ratio of the signal at the segmented high-frequency range and a tone-to-noise ratio of the signal at the low-frequency range to be replicated at the high-frequency range, the tone having signal components that exist intensely at a specific frequency range and the noise having signal components that exist regardless of frequency range;

calculating an adjustment coefficient which is used to adjust tonal characteristics of the signal at the low-frequency range to be replicated at the high-frequency range, based on the tone-to-noise ratios calculated regarding the signals at the low frequency range and the high frequency range; and

generating the coded signal that includes the calculated adjustment coefficient.

[15] The coding method according to Claim 14 further comprising:

determining whether or not a predetermined signal having the tonal characteristics is to be added to the signal at the low-frequency range to be replicated at the high-frequency range, based on the tone-to-noise ratios calculated regarding the signals at the low-frequency range and the high-frequency range; and

generating the coded signal which includes a result of said determining.

[16] A program which is used for a coding equipment for

generating a coded signal that includes information for generating a signal at a high-frequency range by replicating a signal at a low-frequency range, the ranges being segments in a time direction and in a frequency direction, said program causing a computer to execute steps of:

calculating, using linear prediction processing, a tone-to-noise ratio of the signal at the segmented high-frequency range and a tone-to-noise ratio of the signal at the low-frequency range to be replicated at the high-frequency range, the tone having signal components that exist intensely at a specific frequency range and the noise having signal components that exist regardless of frequency range;

calculating an adjustment coefficient which is used to adjust tonal characteristics of the signal at the low-frequency range to be replicated at the high-frequency range, based on the tone-to-noise ratios calculated regarding the signals at the low frequency range and the high frequency range; and

generating the coded signal that includes the calculated adjustment coefficient.